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USSR REPORT

Physics and Mathematics

No. 77

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ACOUSTICS

SURFACE REVERBERATION WITH WAVEGUIDE SOUND PROPAGATION IN OCEAN

ABROSIMOV, D. I. and DOLIN, L. S., Institute of Applied Physics,
USSR Academy of Sciences

[Abstract] The existing theory of sound scattering by the agitated surface
of the sea does not account for the possible influence that effects of
waveguide sound propagation have on characteristics of the received signal.
The authors suggest a modification of the theory for cases where such
effects become appreciable. The analysis is based on a maximally simplified
model of the ocean where a point source of sound pulses is at a given coor-
dinate with predetermined depth dependence of the speed of sound and density.
The surface is statistically uneven, and the bottom is smooth with given
speed of sound and density. It is assumed that the characteristic duration
of the sound pulse emitted by the source is much greater than the carrier
frequency, and that the mean square wave height is small compared with the
wavelength of the sound. The correlation ratio of wave height is also taken
as small compared with the spatial length of the pulse, and the frequency
of the sound is such that absorption in water can be disregarded. The
problem of calculating the sound field scattered by the surface reduces to
solution of the wave equation for sound pressure. Formulas are derived for
calculating the level of surface reverberation with sound propagation in a
waveguide with smooth boundary and known system of eigenfunctions. An
analysis is made of the peculiarities of signal scattering under these
conditions, and especially those associated with interference of sound channel
modes. Figures 4, references 12 Russian.
[98-6610]

1

CONCENTRATED SOUND BEAM PROPAGATION IN THREE-DIMENSIONAL INHOMOGENEOUS MEDIUM

BABICH, V. M. and POPOV, M. M., Mathematics Institute imeni V. A. Steklov, Leningrad Department, USSR Academy of Sciences

[Abstract] The authors consider a three-dimensional medium with continuously varying density $\rho(x,y,z)$ and speed of sound $c(x,y,z)$. Perturbation of pressure P in such a medium (after isolation of the time dependence $e^{-i\omega t}$) satisfies the equation

$$\Delta P + \frac{\omega^2}{c^2} - \frac{1}{\rho}(\nabla\rho, \nabla P) = 0, \qquad (1)$$

where Δ is the Laplace operator, $(\nabla\rho, \nabla P)$ is the scalar product of gradients of the functions ρ and P. Formal asymptotic solutions are found for equation (1) as $\omega\to\infty$. These solutions are appreciably different from zero in some tubular neighborhood of a ray, and damp our rapidly outside of this neighborhood. It is found that the center of such a gaussian beam moves along a geometric-optics ray. Curvatures of the wavefront and the half-widths are expressed in terms of the solution of equations that describe first-approximation rays. References 9 Russian.
[98-6610]

WEDGE EXCITATION OF SURFACE ACOUSTIC WAVES

GULYAYEV, Yu. V., PLESSKIY, V. P. and TEN, Yu. A., Institute of Radio Engineering and Electronics, USSR Academy of Sciences

[Abstract] An analysis is made of excitation of electroacoustic surface waves of pure shear type by a wedge in piezoelectric materials. It is assumed that a cadmium sulfide wedge is used to stimulate shear waves in a lithium niobate crystal. It is assumed that there is no mechanical contact between media, and wave interaction is strictly via the electric field. The amplitude of the excited wave and efficiency of wedge transducer operation are found as a function of the angle of incidence of the body wave and the dimensions of the wedge. Incidence of the shear wave in the CdS crystal is taken as greater than the critical angle, which is the arc sine of the ratio of the wave number of the volumetric shear wave in the substrate material to that in the layer in the case of total internal reflection.

Optimum dimensions are determined for a wedge giving conversion efficiency
of up to 80%. Figures 3, references 5: 3 Russian, 2 Western.
[98-6610]

SYNTHESIZING GEOMETRY OF COPHASED SUBARRAYS IN ACOUSTIC PHASE ARRAY
ANTENNAS

ZHUKOV, V. B., IVANOV, N. M. and MILOSLAVSKIY Yu. K.

[Abstract] In connection with the use of scanning antennas it becomes
necessary to synthesize a subarray configuration enabling efficient phase
scanning. The authors suggest a way of doing this. An acoustic phase array
antenna is synthesized from a predetermined amplitude polar pattern, assuming
that the number of exciters and their polar patterns are known. The scheme
of excitation and control of the array is simplified by breaking the system
down into subarrays with elements connected in parallel. An algorithm is
proposed for sequential filling of the subarrays by the method of directed
sorting. The proposed technique reduces the number of phase inverters in
the excitation system by a factor of four. Figures 4, references 7:
6 Russian, 1 Western.
[98-6610]

CALCULATING UNDERWATER SOUND DAMPING IN SHALLOW SEA

KUZNETSOV, V. K., Moscow State University imeni M. V. Lomonosov

[Abstract] General formulas are derived for sound wave damping in a shallow
sea with consideration of two kinds of normal wave damping: damping on sub-
critical frequencies, and damping due to dissipative losses in the medium.
The author also considers damping in flat waveguides with impedance boundar-
ies. Trajectories are given for displacements of the roots of the disper-
sion equation on the complex plane. Figure 1, references 4: 3 Russian,
1 Western.
[98-6610]

CRYSTALS AND SEMICONDUCTORS

MAGNETOSTRICTIVE SUSCEPTIBILITY OF THIN-FILM ACOUSTIC SURFACE WAVE
CONVERTERS

VERSHININ, V. V. and POL'SKIY, A. I., Institute of Physics
imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences,
Krasnoyarsk

[Abstract] Thin-film magnetostrictive converters of magnetic to acoustic
surface wave energy are considered and the magnetostrictive susceptibility
of such devices is calculated on the basis of phenomenological analysis in
the quasi-static approximation. A thin film is referred to a rectangular
system of coordinates with the plane of the film as the $Z = 0$ plane and the
axis of easy magnetization in the material with induced anisotropy as the
Y-axis. Two variants of magnetostrictive lattice structures have been
evaluated experimentally, both produced from a continuous film by the photo-
lithographic process, with the axis of easy magnetization respectively
parallel or perpendicular to the Permalloy film strips. For both the magneto-
strictive susceptibility of the lattice and the transmission coefficient of
the device as a delay line were measured as functions of the magnetizing
field H_x, H_y. The experimental data confirm the rotational effect along
with domain wall movement in the frequency range below intrinsic ferro-
magnetic resonance. Experiments with piezoelectric excitation and magneto-
strictive reception have also confirmed the validity of the reciprocity
principle in such a system. The authors thank M. Sh. Yerukhimov for the
discussion. Figures 6, references 4: 3 Russian, 1 Western.
[124-2415]

INTERACTION OF SHOCK WAVES WITH SURFACES OF SINGLE CRYSTALS OF SILICON AND
WITH SURFACES OF FILMS IN SiO_2-Si and Al-SiO_2-Si SYSTEMS

MESHCHERYAKOV, N. A., Novosibirsk Institute of Geodesy, Aerial Photography
and Cartography Engineers

[Abstract] Experimental results are presented which characterize the effect
of relatively mild shock waves on the surfaces of Si, SiO_2-Si and
Al-SiO_2-Si. Studies were made of the shock compression of various single
crystals of silicon and of systems of an SiO_2 film or Al-SiO_2 film on silicon
under the effect of shock waves in water and in argon. The experimental
apparatus and procedure are described in earlier studies by the same author
(1967, 1971). Optical reflection spectra were recorded in the visible and
near infrared region of the spectrum, using a Carl Zeiss type SP-M1 unit with
a mirror monochromator and a type DFS-23 diffraction spectrometer. A poly-
crystalline layer, representing the formation of crystal defects, forms
when a shock wave acts on a single crystal. The thickness of this layer
depends on the orientation of the surface and its type and the parameters
of the shock wave, such as pressure and temperature at the wavefront. Curves
are given illustrating changes in the voltage-capacitance characteristics of
a planar thyristor at 1 MHz after the effect of shock waves in argon, before
the effect of the shock wave, and at pressures of 600 and 1200 atm at the
wavefront. Curves are also shown illustrating the change in grain size and
mechanical stresses after the effect of shock waves in water and in argon for
SiO_2-Si, Al-SiO_2-Si and Si, as well as the impurity concentration near the
surface of silicon with various thicknesses of an SiO_2 film after the effect
of shock waves in argon with a wavefront pressure of 30 to 4.) atm and a
temperature on the order of 3000 K. In the latter instance, curves are pre-
sented for p-type and n-type silicon with film thickness of 0.5 and 1 µm.
After the effect of shock waves a shift along the voltage axis takes place
in the voltage-current characteristic, t _ slope ⟨ . this characteristic
changes and the minimum capacitance, C_{min}, is red ed, resulting in a con-
siderable change in the effective surface charge, which in turn is caused
partly by the migration of an impurity near the silicon surface. A change
in the impurity concentration near the surface of monocrystalline silicon
is responsible for the rediction in C_{min} ob rved after the effect of shock
waves with specific parameters. The concen. ration of donors or acceptors
is reduced considerably after the effect of shock waves and the thicker the
SiO_2 film the more considerable the reduction in impurity concentration
throughout the semiconductor's depth. Changes in the concentration of fast
surface states and deep levels in silicon occur because of the substantial
change in the effective charge at the Si-SiO_2 interface after the effect of
shock waves. Figures 4, references 12: 9 Russian, 3 Western.
[76-8831]

SUPERLATTICE CONDUCTIVITY IN STRONG MAGNETIC FIELD

KRYUCHKOV, S. V. and MIKHEYEV, N. P., Volgograd State Pedagogical Institute
imeni A. S. Serafimovich

[Abstract] Electrical conductivity of a narrow-band semiconductor is
theoretically analyzed under conditions of a strong magnetic field with
explicit consideration of scattering of current carriers by optical pho.cns.
This analysis applies to the case of a quantizing electric field, where a
large number of rungs of the Stark ladder fit into the width of the forbidden
band. It is shown that singularities in conductivity should be observed
at $\vec{H} = 0$, and that the result depends appreciably on the width of the for-

bidden band in the longitudinal direction. The results can be attributed
to the fact that in a quasiclassically strong electric field an electron is
able to jump over a large number of rungs of the Stark ladder. However,
in this situation the only contribution to current is from those transitions
where the electron remains within the conduction band. Conservation laws in
the process of quantum transition between Landau levels with absorption or
emission of a phonon imply that $\delta_j = 0$ when $l\omega_e > w - \omega_0$ ($l\omega_e > w + \omega_0$), where

$$\sigma_j = \frac{3eG^2 n kT}{32\pi\Omega\omega_0}\left(1 + \frac{\omega_e^2}{3w^2}\right)[\Theta(w - \omega_e - \omega_0) + \Theta(w - \omega_e + \omega_0)].$$

$$G^2 = 2\pi\omega_0 e^2(\varepsilon_\infty^{-1} - \varepsilon_0^{-1}), \quad V = 1,$$

$\omega_c = eH/mc$, $\Theta(x) = 0$ for negative x and 1 for non-negative x.
References 10: 8 Russian, 2 Western.
[94-6610]

HOW IRRADIATION INTENSITY INFLUENCES BIPOLAR SILICON TRANSISTOR RADIATION
DAMAGE BY PROTONS AND ELECTRONS

BANNIKOV, Yu. A., GORIN, B. M., KOZHEVNIKOV, V. P., MIKHNOVICH, V. V. and
GUSEV, L. I.

[Abstract] The authors analyze the results of irradiating bipolar npn and
pnp transistors on 24-MeV proton linacs and 2-MeV electron linacs. The

transistors were irradiated with protons at average flux density J_{av} from $2.5 \cdot 10^7$ to $4 \cdot 10^{10}$ cm$^{-2} \cdot$s^{-1} (dose rate P_{av} from 8 to $1.3 \cdot 10^4$ rads/s) by pulses with recurrence rate of $f = 1$ Hz and duration $\tau = 5 \cdot 10^{-6}$ s. Intensity was varied by changing the flux density I in a pulse while keeping the ratio J_{av}/I constant at $5 \cdot 10^{-6}$. The current-transfer ratio of the base of the transistors β_{st} was measured at moderate emitter currents where β_{st} is determined chiefly by recombination in the base. The parameter $K_\beta = (1/\beta_\phi - 1/\beta_0)/\phi$ was determined from the linear part of the curve for $1/\beta_{st}$ as a function of integrated proton flux ϕ, where β_0 is the value of β_{st} before irradiation, and β_ϕ is the value after irradiation by flux ϕ. Statistically reliable dependences of the average values of K_β on intensity or irradiation were obtained by simultaneous exposure of 8 transistors. The results show that radiation damage of npn transistors increases by a factor of 8-12 as proton irradiation intensity decreases from $4.07 \cdot 10^{10}$ to $2.5 \cdot 10^7$ cm$^{-2} \cdot$s^{-1}. The damage to pnp transistors behaves oppositely, decreasing by a factor of 2-3 as the intensity of irradiation decreases in the same range. Damage was found to depend on intensity of exposure by protons at a dose rate 3 orders of magnitude lower than was observed for electron irradiation. The results are attributed to the way that reactions of radiation defect formation depend on the charge state of defects with consideration of the part played by formation of resoftening regions with exposure by protons. Figures 3, references 18: 7 Russian, 11 Western.
[94-6610]

PHOTOELECTRIC PROPERTIES OF HEAT-TREATED n-SILICON EXPOSED TO Co-60 GAMMA RAYS

[AKHKAMOV, Sh. and MURATOV, Z.,,Institute of Nuclear Physics, UzSSR Academy of Sciences, Ulugbek

[Abstract] An investigation is made of the influence that gamma irradiation has on the photoelectric properties of n-silicon exposed to heavy doses (up to 10^{19} q/cm^2). A study is also done on the photoionization cross section of radiation-induced defect centers. The spectra of photocapacitance and photoconductivity of the irradiated specimens were measured by the IKS-21 spectrometer at a temperature of 77 K on direct current. The results show that centers are induced in the lower half of the forbidden band with $E_v + (0.32-0.36)$ eV, which are sticking levels for holes. High-temperature heat treatment of n-Si stimulates the process of radiation-induced defect formation, and the rate of introduction of radiation defects is considerably dependent on the concentration of heat-induced defects. Analysis of the spectral dependence of the photoionization cross section for levels

E_c - (0.16-0.20) eV and E_v+0.32 eV shows that the capture cross section for photons by radiation-induced defects is two orders of magnitude lower than for many impurity centers, while the capture cross sections for current carriers are about of the same order of magnitude. Figures 2, references 12: 8 Russian, 4 Western.
[94-6610]

GROWING GIANT CRYSTALS IN OXIDIZING ATMOSPHERE UNDER LASER ACTION

ALIMOV, D. T., ATABAYEV, Sh., BUNKIN, F. V., ZHURAVSKIY, V. L., KIRICHENKO, N. A., LUK'YANCHUK, B. S., OMEL'CHENKO, A. I. and KHABIBULAYEV, P. K.

[Abstract] The properties of surface compounds synthesized under thermally nonequilibrium conditions of laser heating may be considerably different from analogous properties of compounds produced under isothermal conditions. This paper is a report on experimental observation of a new effect: formation of "giant" cuprous oxide crystals when copper targets are heated in an oxidizing atmosphere under the action of CO_2 laser radiation. A cw laser with power of 40 W was used to irradiate the surface of a target 0.7 cm square and 1-2 mm thick. The maximum temperature of the target was close to the melting point of copper. The resultant oxide film consisted of Cu_2O with a thin layer of CuO that was readily removed by etching with NH_4Cl. Heating time of 10-12 minutes yielded a cuprous oxide film 100-150 μm thick. X-ray structural analysis showed that the film grows in the form of small crystals. It was simultaneously observed that in a comparatively narrow range of parameters (such as the radiation mode structure and intensity, dimensions of the spot and the target, etc.), individual "giant" crystals of cuprous oxide are synthesized. These crystals rise above the surface, reaching a height of 5 mm and diameter of about 0.5 mm. Growth rate is about 0.3 mm/s. The growth process accelerates abruptly after an activation time of about 10 minutes, formation of the principal mass of the giant crystal occurring within 10-15 s. Growth in all cases was in the direction of the laser beam. The effect is attributed to development of thermodiffusional instability due to high temperature gradients. Figure 1, references 3 Russian.
[118-6610]

FLUID DYNAMICS

ACCURACY OF VELOCITY MEASUREMENT ON OBJECTS MOVING BEHIND TURBULENT LAYER

LUKIN, I. P.

[Abstract] The accuracy of velocity measurement on objects moving outside
the atmosphere with an optical interference radar is estimated in the approxi-
mation of a thin stochastic interference grid formed through the layer of
atmospheric turbulence by two mutually coherent ground sources of optical
radiation. Calculations are based on the Huygens-Kirchhoff principle for
the Fresnel zone of the transmitters. The vertical interference pattern
is used for determining the tangential component of velocity of a moving
object that carries a square-law detector. Expressions are derived for the
width of the finite interference pattern involving Gaussian light beams
with given initial field distributions at the detector aperture and for the
resulting velocity measurement error compounded by the error due to turbulence,
taking into account that the spectral density of permittivity does not neces-
sarily obey Kolmogorov's law. Figure 1, references 7: 5 Russian,
2 Western.
[127-2415]

AMPLITUDE CHARACTERISTICS OF THREE-DIMENSIONAL INTERNAL WAVES IN OCEAN CURRENTS

SUVOROV, A. M., TANANAYEV, A. N. and CHERKESOV, L. V., associate member,
UkSSR Academy of Sciences, Marine Hydrophysics Institute, UkSSR Academy
of Sciences; Sevastopol' Instrument Making Institute

[Abstract] A general formulation is given for the problem of unsteady
three-dimensional internal wave motion in the sea approximated by a liquid

with N layers of different densities and current velocities. Specific numerical calculations are given for the amplitude characteristics of internal waves. The equations, boundary co..ditions and initial conditions in the linear theory are written in a coordinate system fixed to the moving region of atmospheric pressure perturbations using Fourier and Laplace transforms, giving an exact solution of the problem within the framework of the linear theory that describes displacement of the boundary of layers of the liquid from the undisturbed state. This solution is valid even when the flow of stratified liquid is unstable with respect to perturbations caused by an external source. However, in this case the solution describes wave motion only during the initial time segment when the wave amplitude is small enough that nonlinear effects can be disregarded. At higher amplitudes, equations and boundary conditions must account for nonlinear terms. An investigation is made of the influence that shear flow has on wave behavior. Figures 2, references 3 Russian.
[97-6610]

DISTINCTIVE FEATURES OF Q-SWITCHING IN OPTICAL CAVITY BY MEANS OF
MANDEL'SHTAM-BRILLOUIN STIMULATED-SCATTERING MIRROR

VASIL'YEV, M. V., LESHCHEV, A. A., SEMENOV, P. M. and SIDOROVICH, V. G.

[Abstract] An earlier experiment with a laser and an optical cavity
revealed triggering of a monopulse by a light beam moving within a very
narrow channel through the resonator cavity formed by a flat mirror and a
Mandel'shtam-Brillouin stimulated-scattering (MBSS) mirror. This effect
was subsequently utilized for Q-switching in such a cavity with neodymium
glass as active medium inside, by means of an MBSS mirror placed before the
waveguide. The radiation spectrum and the energy distribution were measured
in these experiments, a four-wave MBSS mirror having been found to give
exact wavefront reversal. It this appears feasible to improve both the
spatial coherence and the directivity of laser radiation by forming the
resonator with a flat mirror and an MBSS mirror. The authors thank
Yu. N. Denisyuk for support of this study and N. A. Sventsitskiy for
helpful suggestions. Figures 6; references 10: Russian.
[124-2415]

ANALYSIS OF STIMULATED ULTRASHORT PULSE EMISSION WITH SYNCHRONOUS PUMPING
OF FOUR-LEVEL MEDIA

NEKHAYENKO, V. A., Department of General Physics and Wave Processes,
Moscow State University

[Abstract] The author considers an active medium approximated by the
model in the diagram with fast times of vibrational relaxation

$T_2 \ll 1/W_{43} \approx 1/W_{21} \ll \tau_p$ (pumping pulse duration), and slow population lifetime T_1 $(1/T_1 W_{43} \ll 1)$ of level 3. Relaxation W_{12} takes account of weak $(W_{12}/W_{21} = \gamma \ll 1)$ equilibrium population of level 2, including the effect of self-absorption of the emitted pulse. Lasing in such a medium is analyzed for the superluminescent mode, synchronous pumping by a finite train of a fixed number of pulses and by a continuous pulse train. Expressions are derived for the pumping and lasing intensities and the lasing fields. Figures 2, references 3: 2 Russian, 1 Western.
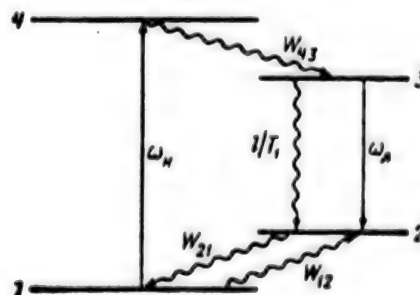
[102-6610]

INFINITESIMAL THIN-FILM RING LASER

CHEREMISKIN, I. V. and CHEKHLOVA, T. K.

[Abstract] Previous research provides information for a thin-film ring laser with diameter of 1-10 mm. This paper is devoted to development of such a laser with close to minimal dimensions. The limiting diameter of the thin-film ring laser is determined by the radiation from a waveguide bend, which increases with decreasing radius of curvature. Analysis of results of calculations for different radii of curvature shows that radiation losses at a radius of curvature less than 23 μm are so great that it is practically impossible to further reduce the size of the laser. Experiments were done with a glass fiber coated with gelatin containing rhodamine-6G dye pumped by the second dynamic of a neodymium laser. The emission was coupled out by a prism to a spectrograph with resolution of 13 Å/mm. A laser of this kind is made with rod radius of 55 μm. The small radius of the thin-film ring laser enables good resolution of the mode structure of the spectrum and reveals singularities involving reduction of emission intensity within the line of the amplification band, and also relative displacement of emission spectra for waves propagating in opposite directions in the optical cavity. Figures 2, references 5: 2 Russian, 3 Western. [99-6610]

He-Xe LASER OUTPUT POWER ON $\lambda = 3.3676$ µm AS FUNCTION OF ACTIVE MEDIUM PARAMETERS

KIRSANOV, A. V., POPOV, A. I. and SADCHIKHIN, A. V.

[Abstract] An investigation is made of the energy capabilities of the He-Xe laser transition with wavelength of 3.3676 µm as a function of parameters of the active medium. The maximum power from a unit of length of the active medium is experimentally determined as dependent on the ratio of partial pressures of helium and xenon, the total pressure of the gas mixture and the discharge current for a gas-discharge tube 6 mm in diameter with discharge excited by direct current. In the region of lasing maxima, the transition showed a gain of 2.8, 3.1, 2.8 and 2.4 m^{-1} for He:Xe ratios of 0, 10, 22 and 47 respectively. Maximum power from a unit of length of the active medium is 47 mW/m realized at He:Xe ratio of 22, total pressure of 200 Pa and discharge current of 25 mA. Because of the poor optical quality of the discharge windows, the experimentally attained maximum was only 15 mW. Nevertheless, experiments have shown that this is adequate power for analyzing hydrocarbon mixtures for methane content and the sum of higher hydrocarbons. Figure 1, references 3: 2 Russian, 1 Western. [105-6610]

IMPROVING OXAZINE 17 LASING EFFICIENCY BY ELECTRON ENERGY TRANSFER FROM STIMULATED RHODAMINE DYE MOLECULES

REVA, M. G., AKIMOV, A. I., DENISOV, L. K. and UZHINOV, B. M.

[Abstract] The use of donor-acceptor pairs for energy transfer in dye lasers is quite promising as a means of improving parameters of stimulated emission. The authors study processes of energy transfer in a mixture of oxazine 17 and rhodamine dyes in ethanol, and investigate lasing efficiency of oxazine 17. Systems with oxazine as the acceptor and rhodamine 6G and rhodamine C as the donor were studied in a nonselective optical cavity with lasing stimulated in a transverse arrangement by emission on the second harmonic of a ruby laser; wavelength 347 nm. The opaque mirror was aluminized, and the output mirror had reflectivity of 50-60%. Power density of the stimulating light was 20 MW/cm^2, and pulse duration was 20 ns. Flashlamp excitation was also used with pulse energy of 200 J at pulse duration of

3 μs and rise time of 1.5 μs. The spectral characteristics of the given mixtures show that rhodamine dyes not only increase the lasing efficiency of oxazine 17, but also expand the tuning range of stimulated emission. It is established that energy transfer from the rhodamine dye molecules takes place by a radiative mechanism for both coherent and flashlamp pumping. Figures 2, references 4 Western.
[100-6610]

INFLUENCE OF MANDELSTAM-BRILLOUIN MIRROR ON TIME STRUCTURE OF SOLID-STATE LASER RADIATION

KORNIYENKO, L. S. and SERKIN, V. N., Moscow State University imeni M. V. Lomonosov

[Abstract] An effective method for passive Q-switching of a solid-state laser is to use a medium that induces Mandelstam-Brillouin scattering (Mandelstam-Brillouin mirror). Until the time of this paper, there has been no analysis of a laser system using such a mirror with consideration of the fine time structure of the radiation on the period of the cavity, and specifically no analysis of mode-locking. The authors examine the dynamics of stimulated emission in a solid-state laser with Mandelstam-Brillouin mirror. A characteristic feature of such laser systems is that there are two thresholds: a free-lasing threshold (spike emission) and a Q-switching and mode-locked threshold (emission of a train of ultrashort pulses). In this paper the authors find the conditions of the second threshold and the range of variation of the principal laser parameters within which the Mandelstam-Brillouin mirror leads to a sequence of powerful ultrashort pulses with high contrast of radiation. It is shown that the Mandelstam-Brillouin mirror effect is analogous to that of a nonlinear filter that isolates a maximum spike in the time structure of the emission. Calculations demonstrate the feasibility of ultrashort pulse generation in a solid-state laser with a "long" Mandelstam-Brillouin mirror in the mode of steady-state scattering at saturation. Of considerable interest is the possibility of attaining mode locking and wavefront reversal simultaneously in solid-state lasers with Mandelstam-Brillouin mirrors. References 6 Russian.
[118-6610]

INVESTIGATICN OF LIQUID NEODYMIUM AMPLIFIER IN WAVEFRONT REVERSAL ARRANGEMENT

ANAN'YEV, Yu. A., GRISHMANOVA, N. I., SVENTSITSKAYA, N. A. and
SOLOV'YEV, V. D.

[Abstract] An investigation is made of the feasibility of using wavefront
reversal to compensate for the thermo-optical distortions of the optical
cavity that result in radiation divergence detrimental to the advantages
of neodymium-doped liquid laser media. Experiments were done with a laser
cell 15 mm in diameter and 200 mm long filled with $POCl_3:SnCl_4:Nd^{3+}$ and
placed in a four-lamp illuminator. Under typical pumping conditions this
laser had an output energy of 20-30 J in a flat optical cavity without
Q-switching. The pulse to be amplified was produced by a neodymium-doped
glass monopulse laser with spectral and spatial filtration systems. Pulse
duration was 50 ns, beam diameter was 15 mm, and divergence was about
$5 \cdot 10^{-4}$ rad. Spectral width was $4 \cdot 10^{-4}$ nm. The wavefront-reversal device
was a Mandelstam-Brillouin mirror with focusing of the emission in a cell
30 cm long filled with an analogous liquid without pumping. The use of
other scattering media such as xenon and acetone had no appreciable effect
on the results. Wavefront reversal was found to reduce the divergence of
the beam to $2 \cdot 10^{-3}$ rad as compared to $2 \cdot 10^{-2}$ rad without the Mandelstam-
Brillouin mirror. References 3 Russian.
[118-6610]

INFLUENCE OF AUGER RECOMBINATION ON SEMICONDUCTOR INJECTION LASER THRESHOLD CHARACTERISTICS

LUBASHEVSKIY, I. A., RYZHIY, V. I. and SURIS, R. A.

[Abstract] Heating of the electron gas due to Auger recombination is
suggested as one of the factors responsible for the fact that the threshold
pumping current of injection lasers is independent of lattice temperature
at low temperature levels. It is shown that the curve for electron gas
temperature as a function of injection current may be S-shaped in infrared
semiconductor lasers, and when the forbidden band is sufficiently narrow,
the temperature that gives rise to population inversion is independent of
lattice temperature at low temperature levels. The analysis is based on a
narrow-gap semiconductor of the $Pb_{1-x}Sn_xTe$ type. It is shown that for in-
jection lasers based on such semiconductors the threshold pumping current
begins to depend on lattice temperature only when the electron temperature
is of the order of $E_1 \sim 0.1\Delta E_g$, where E_1 is the product of the width of the
forbidden band multiplied by the ratio of the transverse to longitudinal
mass of the electron. Figure 1, references 4: 1 Russian, 3 Western.
[118-6610]

TRAVELING-WAVE LASER PRODUCED BY SOUND PULSE IN ACTIVE MEDIUM

GULYAYEV, Yu. V. and SHKERDIN, G. N., Institute of Radio Engineering and
Electronics, USSR Academy of Sciences, Moscow

[Abstract] An analysis is made of effects that may arise in an active
medium when distributed feedback is induced by short acoustic pulses where
the spatial dimensions of the pulse are considerably shorter than the length
of the active medium in the direction of sound propagation. In this case,
when the reflection of light from the ends of the active region is sufficient-
ly low, feedback will be set up only in the region of acoustic pulses, and
if these pulses are powerful enough, the laser emission may to a considerable
extent be trapped inside the pulses of the sound wave. Conditions for such
trapping are found by analysis based on the theory of distributed feedback
produced by a cw acoustic signal. It is shown that the power of the laser
emission trapped in such a traveling wave may considerably exceed that for
an analogous stationary optical cavity. When the sound pulse leaves the
crystal, the trapped radiation is emitted in a kind of "giant" pulse.
References 4: 1 Russian, 3 Western.
[118-6610]

INFRARED SIGNAL REFLECTION ACCOMPANYING DEGENERATE FOUR-PHOTON PARAMETRIC INTERACTION IN SF_6

BALITSKIY, S. D. and BOLOTSKIKH, L. T., Institute of Physics
imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences,
Krasnoyarsk

[Abstract] An experimental study is done on complex-conjugate reflection
of pulsed CO_2 laser emission accompanying degenerate four-photon interaction
in SF_6. At pumping intensities of 1.6 MW/cm^2, the conversion coefficient
attained on line R(6) ($\lambda = 10.34$ μm) reached 58%, which is apparently not a
limiting value. The pumping source was a TEA CO_2 laser with frequency tuning
by diffraction grating. The pumping emission passed through the cell con-
taining SF_6, and 50% of the output was reflected back by a germanium mirror
to produce a counter pumping wave. A beam splitter arrangement reflected
the signal wave back to the cell at an angle of 6° with focusing to improve
beam overlap. The reflected signal was filtered and recorded by a nitrogen-
cooled Au-Ge photocell and an oscilloscope. The maximum conversion co-
efficient of 58% was reached at SF_6 pressure of 153 mm Hg. Measurements
at this pressure showed that the conversion coefficient is a square-law
function of pumping power. Figures 2, references 9: 3 Russian, 6 Western.
[118-6610]

FERROELECTRIC DOMAINS AND LASER FREQUENCY DOUBLING IN $Ba_2NaNb_5O_{15}$ CRYSTALS

ALEKSANDROVSKIY, A. L., Department of Crystal Physics, Moscow State University

[Abstract] An unusual type of lasing in polydomain crystals of barium-sodium niobate was first observed by A. A. Ballman et al. [see J. CRYSTAL GROWTH, Vol 10, No 2, 1971, pp 185-189]. In this paper, the author studies such lasing for two principal modifications of the domain structure of barium-sodium niobate crystals: laminar structure, and structure consisting of microdomains. Data are also given on second-harmonic lasing in ferro-electric cyrstals related to barium-sodium niobate: barium-lithium niobate and potassium-lithium niobate. A theory of nonlinear scattering of light by domains is used to interpret the experimental data. The source of radia-tion on a wavelength of 1.06 μm was an LTI-5 laser in single-mode operation with recurrence rate of 12.5 Hz. The laser beam passed through the specimen perpendicular to the polar axis Z and parallel to axis X. The direction of oscillations of the electric vector of the light wave coincided with the Z-axis. In this arrangement, emission on 0.53 μm had polarization coinci-dent with that of the incident beam. Diffuse scattering of the second harmonic was observed for crystals with unordered domain structure consisting of microdomains. It is concluded that the size of the microdomain-needles in the direction of the polar axis of the crystal is about 10 μm, while the transverse dimension is 1-3 μm. On crystals with periodic laminar domain structure (period of 12 μm) a quasisynchronous noncollinear second-harmonic lasing process is obtained with angular width of the lasing peak of 22'. Such a process can be used for laser frequency conversion. Analogous results are realized with the other crystals. Figures 3, references 8: 3 Russian, 5 Western.
[102-6610]

DEFORMATION MECHANISM FOR ACOUSTIC CONTROL OF SEMICONDUCTOR LASER EMISSION

BUGAYEV, A. S., GODIK, E. E. and GULYAYEV, Yu. V., Moscow Physicotechnical Institute

[Abstract] In recent years, researchers have been studying the feasibility of using sound to control semiconductor laser emission. So far, the emphasis has been on Bragg diffraction of laser emission by sound for Q-switching either by creating acoustic distributed feedback, or by acoustic

tuning of an ordinary mirror cavity. In this paper, the authors study the possibility of controlling semiconductor laser emission by using a sound wave to change the gain of the active medium. Electron-photon interaction via the deformation potential in semiconductors results in modulation of the width of the forbidden band and bunching of charge carriers in crystal regions corresponding to energy minima. If the direction of propagation of the sound is selected so that the constants of deformation potentials for electrons and holes have opposite signs, the approach of the band edges and bunching of electrons and holes will take place in the same regions of the crystal. When the intensity of sound is strong enough, population inversion may be realized in these regions. The specific analysis of the effect is based on a gallium arsenide injection laser. It is shown that the relative increase in intensity I of emission when the sound wave is switched on is $(I - I_{th})/I_{th} \sim \gamma \Delta n/n$, where I_{th} is emission intensity at the lasing threshold, γ is the slope of the current-power curve of the laser at the working point, $\Delta n/n$ is the change in carrier concentration. The intensity of the sound wave S determines $\Delta n/n$:

$$S \sim \rho v_s^3 (\frac{T_F}{\Lambda} \frac{\Delta n}{n})^2, \text{ where } \rho \text{ is the density}$$

of the crystal, T_F is the Fermi energy, Λ is the deformation potential. It is shown that for a laser with $\gamma \sim 100$, the required $\Delta n/n \sim 10^{-1}$ for controlling emission: $(I - I_{th})/I_{th} \sim 10$. The required sound intensity is about 100 W/cm^2. For a laser diode measuring 0.01 x 0.01 x 0.001 cm, the power of the sound introduced into the diode must be of the order of 1 mW. The frequency of the sound wave must be between 10^7 and 10^9 Hz. The spectaal width of the emission line and the radiation pattern can be varied by changing the frequency and intensity of the controlling sound wave. The proposed method is also applicable to superluminescent LEDs if higher sound powers are used to compensate for the shallower slope of the current-power curve. References 5: 3 Russian, 2 Western.
[101-6610]

MAGNETOHYDRODYNAMICS

TYPES OF POSSIBLE MAGNETOHYDRODYNAMIC INSTABILITIES OF DENSE METAL
VAPOR PLASMA

RUTKEVICH, I. M. and TOKAR', P. M., Institute of High Temperatures,
USSR Academy of Sciences

[Abstract] A systematic investigation is made of short-wave instabilities
of various types in a dense nonideal moving metal vapor plasma in the
presence of a magnetic field with consideration of gradients of the ground
state. An asymptotic method is proposed for solving the local dispersion
equation in the formalism of perturbation theory based on linearizing
a general system of equations that describes the dynamics of an equilibrium
plasma in the one-fluid approximation. An analysis is made of linear inter-
actions of short-wave perturbations and their dynamics when phase velocities
and local increments are spatially inhomogeneous, and conditions for exci-
tation is influenced by the behavior of electric conductivity specific to
a nonideal plasma. The paper also examines regions of existence of acoustic,
superheating and vortex instabilities of a nonideal plasma during flow in
a channel of fixed cross section. The results show that a variety of MHD
instabilities can arise in a dense nonideal alkali metal vapor plasma.
For mutually orthogonal orientation of the undisturbed electric current
and magnetic field, mechanisms of acoustic instability occur in perturbation
configurations that are different from a plasma of combustion products.
Superheating and vortex instabilities may arise when a dense plasma flows
in an MHD channel. These instabilities should be considered when studying
magnetogasdynamic flows and when analyzing the influence of Joule heat on
dense metal vapor behavior in a magnetic field. Figures 3, references 21:
17 Russian, 4 Western.
[110-6610]

THERMAL BREAKDOWN IN INTERELECTRODE GAP OF MHD GENERATOR CHANNEL WITH
SLAG FILM

MEYTLIS, V. P. and FILONENKO, N. N., Institute of High Temperatures,
USSR Academy of Sciences

[Abstract] An MHD generator operating on coal combustion products has a slag
layer on the walls. Since the conductivity of the slag is considerably
higher than plasma conductivity at the same temperature, it is possible that
the slag film may reduce the critical field at which interelectrode break-
down occurs. The authors consider one of the most probable mechanisms of
breakdown of the slag film filling the interelectrode region: thermal
breakdown that develops as superheating instability. The slag film is
modeled by a plane-parallel slag-filled layer of infinite extent bounded
by two nonconductive solid surfaces separated by a fixed distance maintained
at different temperatures. An estimate is made of the critical field under
conditions typical of an open-cycle MHD generator. The results show that
movement of a slag film has no effect on the critical parameters that
determine development of thermal breakdown. Figures 4, references 6:
4 Russian, 2 Western.
[110-6610]

METHOD OF INTRODUCING ARTIFICIAL DISSIPATION IN VARIATIONAL-DIFFERENCE
MHD SCHEMES

GOLOVIZNIN, V. M., Moscow

[Abstract] The Hamilton least action principle can be taken as a basis for
constructing discrete mathematical models of magnetohydrodynamics. The re-
sultant differential-difference schemes are totally conservative and
conserve entropy of the discrete medium. To make these equations suitable
for claculating flows with shock waves, artificial dissipative processes
must be introduced. The author considers a linear approximation of differen-
tial-difference equations of magnetohydrodynamics, and proposes a method
of introducing linear artificial viscosity based on accounting for the
spectral properties of acoustic equations. Examples of one-dimensional and
two-dimensional numerical calculations show that pseudoviscosity introduced
on the basis of a spectral matching method makes shock wave profiles monotonic

and dissipates the wave fronts. The proposed method of introducing linear
artificial viscosity generalizes in a natural way to cases of higher spatial
dimensions, arbitrary coordinate systems, and also where other physical
factors are present in the medium in addition to the magnetic field, as
long as they do not influence entropy. References 9: 8 Russian,
1 Western.
[111-6610]

NUCLEAR PHYSICS

UNDULATORY BUNCHER OF CHARGED-PARTICLE BEAMS

BESSONOV, Ye. G. and SEROV, A. V., Institute of Physics
imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Two undulatory bunchers of relativistic electron beams are
described, a wave buncher where the undulator parameters vary. The performance
of these devices as modulators for sources of coherent spontaneous undulatory
radiation is analyzed on the basis of the appropriate equation of motion for
electrons in an electromagnetic field, this equation having been solved by
numerical integration according to the Runge-Kutta method with fourth-order
accuracy. Both devices reduce the amplitude of phase oscillations of elec-
trons during slow variation of undulator and wave parameters so that all
electrons of a beam with a wide energy spectrum are retained within the
region of stable phase oscillations and bunched into clusters with a small
phase spread. A wave buncher is simpler in construction but imposes more
severe constraints on the injected beam, while a magnetic buncher requires
more precise matching of the laws according to which the magnetic field and
the bunching pitch respectively vary. It may be possible to eliminate all
these drawbacks in a hybrid device. Figures 2, references 7: 6 Russian,
1 Western.
[124-2415]

ACTIVATING MATERIALS BY ION IMPLANTATION

BULGAKOV, Yu. V. and SAVEL'YEVA, L. M., Scientific Research Institute of
Nuclear Physics

[Abstract] A method of ion activation is proposed for radioactive tracer
techniques using cesium isotopes with atomic numbers 134 and 137. Since
cesium ions are readily produced on hot tungsten, simple ion sources are
available with nearly 100% efficient use of the working substance, which
solves the problem of radiation safety. The activation facility consists
of the ion source and a vacuum chamber in which the object to be activated
is placed. The principal component of the ion source is a tungsten filament
coated with sintered tungsten powder. Before exposure, a droplet of a solu-
tion containing one of the cesium isotopes (Cs_2SO_4 or $CsCl$) is placed on the
surface of the filament. After evacuation to about 10^{-5} mm Hg, an accelerat-
ing voltage of 50-70 keV is applied to the source and the filament is
heated to about 1000°C. The implantation process lasts for about 1 minute.
The method has been successfully used for tracer-tagging aluminum, copper,
iron and other materials including polymers. The tags are resistant to
solvents and withstand prolonged heating at temperatures up to 400°C on
steel and aluminum alloy workpieces. The technique is applicable to
studies of wear of machine parts. Figure 1, references 4: 3 Russian,
1 Western.
[102-6610]

SYNTHESIZING HYBRID OPTICAL DIGITAL STEREOHOLOGRAMS

KARNAUKHOV, V. N., MERZLYAKOV, N. S. and OVECHKIS, Yu. N., Institute of
Problems of Information Transmission, USSR Academy of Sciences, Moscow

[Abstract] Recording of hybrid optical-digital holograms and stereo-
holograms by the "rainbow" method is described, an advantage of this method
being elimination of vertical parallax by irising with a narrow slit. The
real image of an object can be formed on the photographic film with the
aid of another (primary) hologram by the two-step Benton process, or by the
single-step process using a lens with a large aperture. The reference beam
is made to impinge at an angle with the object beam in the vertical plane and
at a small angle to the horizontal plane. As a result, chromatism will
appear in the vertical direction, where parallax has been eliminated, but
hardly at all in the horizontal direction. The mechanism of this method is
demonstrated by analysis of the geometrical optics of the system including
the eye, with the angular image blurring due to chromatic aberration cal-
culated both as a function of geometrical parameters and as a function of
the spectral sensitivity of the reflection hologram. The method has been
tested on hybrid reflection and transmission holograms and stereoholograms
in black and white. It is also applicable to recording of hybrid color
holograms based on use of three principal colors. The authors thank
L. P. Yaroslavskiy for having brought this problem to their attention.
Figures 2, references 10: 4 Russian, 1 Czech, 1 Hungarian, 4 Western.
[124-2415]

OPTICAL PARAMETERS OF AMORPHOUS CdP_2 LAYERS

POTYKEVICH, I. V., MAKSIMOV, V. K., BORSHCH, V. V. and KRIVUTENKO, A. I.

[Abstract] The optical parameters of amorphous CdP_2 layers were measured
on 0.03-0.8 µm thick specimens which had been deposited on glass, quartz
crystal, muscovite, NaCl and KBr substrates under a vacuum of the order of
$2 \cdot 10^{-5}$ torr. The refractive index n and the attenuation factor k as well
as their dispersions were determined from maximum and minimum transmission
coefficients, these having been measured by a method of interference spectro-
photometry particularly suitable for materials with n>>k. Both parameters
were calculated as functions of the wavelength and as functions of the film
thickness. According to the data, they both decrease linearly with increasing
film thickness (except on NaCl and KBr substrates, where the refractive index
of amorphous CdP_2 remains almost constant and the same for both substrates).
As the wavelength increases from 0.9 to 10 µm, the range covered by measure-
ments at room temperature, both n and k first decrease sharply to a minimum
at $\lambda = 2$ µm (n = 3.1-4.0, k = 0.15-0.20) and, while k begins to level off
here, n then increases somewhat before levelling off. Figure 1, references
5 Russian.
[127-2415]

MATHEMATICAL THEORY OF MULTICHANNEL PHOTORECEIVER WITH OVERLAPPING
SPECTRAL CHARACTERISTICS OF CHANNELS

SHAKHIDZHANOV, S. S.

[Abstract] A mathematical model of an m-channel color photoreceiver with
time-invariant characteristics is constructed, such a device being useful
for direct detection and discrimination of unmodulated color signals with an
intricate spectral content. The problem is to determine the maximum number
of color signals within a given set of such signals that the photoreceiver
can discern pariwise after each signal has been measured once within a given
period of time. A correspondence is established between the characteristics
of the set of color signals to be discerned and the volume of the region in
the m-dimensional space that contains points with coordinates or endpoints
of vectors describing the states at the photoreceiver output. On this
basis the color resolution is calculated with the inequality defining the
entire set of color signals then extended to an inequality defining the

entire set of color objects that generate these signals. The operating
conditions and the performance of two color photoreceivers can be best
evaluated comparatively, i.e., a real device compared with the ideal one
not on the basis of the respective color resolutions but on the basis of
the ratio of respective integral signal intensities at which the color re-
solution in each will be the same. One important performance character-
istic is the detection threshold for color contrast. The author thanks
L. N. Kurbatov and V. V. Osipov for the interest and fruitful discussion.
Figures 4, references 12: 8 Russian, 1 Hungarian, 3 Western.
[127-2415]

ACCURACY OF INTERFERENCE METHODS OF DETERMINING OPTICAL PARAMETERS OF
THIN LAYERS

ZHITARYUK, V. G. and GUMINETSKIY, S. G.

[Abstract] Interference methods are used wherever possible for determining
the optical characteristics of thin films. Just as all spectrophotometric
methods, they involve measurement of transmission and reflection coefficients
at interfaces in the air-film-substrate system and subsequent mathematical
evaluation of the readings. The corresponding equations are solved for the
refractive indes and the absorption coefficient of the film. Here various
methods of such an evaluation are compared for accuracy: 1) Gisin-
Konyukhov-Nesmelov iteration based on exact mathematical relations without
simplifying assumptions, 2) Lyashchenko-Miloslavskiy or Valeyev successive
approximations, very simple but sensitive to the fringe order of one or
another extremum point in the interference pattern, 3) Cheremukhin-
Kiriyenko-Gurdin simulation based on the theory of a Fabry-Perot inter-
ferometer and representation of a film on a substrate as a degenerate Fabry-
Perot etalon. These methods are compared on the basis of the relative errors
they yield for the film thickness, the refractive index and the absorption
coefficient. Tables 2, references 9: 8 Russian, 1 Western.
[127-2415]

OPTICAL CHARACTERISTICS OF PHASE PROFILOGRAPHS WITH SIGNAL RECORDING ON
SUBSTRATE SIDE

ALEKHIN, V. A. and GUSHCHO, Yu. P.

[Abstract] The performance of a phase profilograph with data recording on
the substrate side is calculated, such a device combining the higher re-
solving power of a charged layer with the longer life of an uncharged layer.
The deforming forces, particularly surface tension, are calculated from the
solution to the Laplace equation for the electric field at the boundary
between two different dielectric media. The luminous efficiency is calcu-
lated as a function of the space frequency in the geometric optics approxi-
mation. Typical efficiency-frequency characteristics have been thus obtained
for a Newtonian layer and for a viscoelastic layer in the case of a sinusoidal
profile and use of a schlieren projector. The corresponding expressions
describing the steady-state characteristics will yield the transient charac-
teristics when integrated with respect to time, taking into account the
variation in time of the profile depth in the deformed layer. Figures 3,
references 5 Russian.
[127-2415]

SHARPENING CONTRAST OF IMAGE RECORDED THROUGH SCATTERING LAYER IN PARTIALLY
COHERENT LIGHT

IVAKIN, Ye. V. and KITSAK, A. I.

[Abstract] A method of improving the quality of images recorded under
conditions of light scattering is described, namely recording holograms of
a focused image without reference beam in light with partial spatial co-
herence. Obtaining a speckle structure with sharp contrast in such a holo-
gram of a diffuse object requires that the radius of spatial coherence of the
quasi-monochromatic light source be much larger than the width of the pulse
response function of the optical system. An optimum ratio of these two
dimensions, yielding the sharpest contrast, was found to exist in an experi-
ment with a single-mode argon laser for recording the image of a figure drawn
on frosted glass. The radiation from the laser was focused with a lens onto
the plane of a fast rotating disk frosted on one side. The "positive" image
formed through diffraction on the speckle structure was reconstructed by a
helium-neon laser and the zeroth-order (axial "negative" image) was eliminated

by spatial filtration. In a similar experiment a diffuse transparency
served as object and a DATs-50 gas-discharge tube with a red filter served
as light source. The authors thank E. P. Zega for helpful discussions and
A. N. Brindikov for assistance in performing the experiments. Figures 3,
references 12: 5 Russian, 7 Western.
[127-2415]

POSSIBLE APPROACH TO SOLVING 'PHASE' PROBLEM OF COHERENCE THEORY

BAKUT, P. A., SVIRIDOV, K. N. and USTINOV, N. D.

[Abstract] The authors consider the problem of reconstructing the phase
of the function of mutual coherence of the field from an object with
measurements of the amplitude. The approach is based on predetector sym-
metrization of the field and measurements of the real and imaginary parts
of the function. The symmetric function is obtained by using an interferom-
eter correlator. Application of the proposed approach to observational
astronomy enables solution of the problem of "seeing" through a turbulent
atmosphere with nearly real-time elimination of not only the phase distor-
tions caused by atmospheric turbulence, but also distortions of the light
signal caused by mechanical instabilities and vibrations of the viewing
optical systems. Thus the requirements for rigidity of optical systems
can be reduced along with cost. References 12: 5 Russian, 7 Western.
[99-6610]

EFFICIENT HOLOGRAM RECORDING BY PULSED LASER EMISSION ON BICHROMATED GELATIN

MAYER, B. O. and STASEL'KO, D. I.

[Abstract] An investigation is made of the limiting possibilities of re-
cording high-efficiency holograms on bichromated gelatin in the pulsed
mode of illumination, and the parameters of such holograms are compared
with the parameters achieved when using cw laser emission for recording.
The bichromated gelatin layers were prepared by L. H. Lin's method using
Soviet industrial photographic plates. In the pulsed mode the recordings
were made on a wavelength of 530 nm on the second harmonic of a monopulse
neodymium laser at pulse duration of $3 \cdot 10^{-8}$ s and energy density on the
photographic emulsion of 1.5 J/cm^2. In the cw mode, an LG-106M argon

28

laser was used with wavelengths of 515 or 488 nm. Plots of diffraction efficiency as a function of exposure show that both pulsed and cw lasers give a maximum diffraction efficiency of 65-70%. However, the exposure required for maximum diffraction efficiency increases from 150-400 mJ/cm^2 with cw lasers to 1 J/cm^2 with pulsed lasers. Figures 2, references 8: 4 Russian, 4 Western.
[99-6610]

OPTICAL TRANSFER FUNCTION OF CLOUD LAYER MODEL FOR LINEARLY POLARIZED LIGHT

GAVRILOVICH, A. B., GANICH, P. Ya. and IVANOV, A. P.

[Abstract] The authors study distortion of an optical image as it passes through a cloud layer from an object that is a source or reflection of polarized emission. The spatial distribution of brightness along the horizontal axis is measured in experiments in a pool of water measuring 5 x 2 x 2 m. The cloud layer was simulated by a milk emulsion in the water between two planes of a film having relative index of refraction close to unity. The thickness of the emulsion layer was 15 cm. Parallel to the layer and 26 cm below it was a strip light source 1 cm wide. The emission was linearly polarized by a polaroid filter with the electric vector oriented along the strip. A brightness meter with slit considerably narrower than the image of the source was used for measurement with a polaroid and light filter isolating a wavelength of 546 nm. The optical density of the milk emulsion was varied to simulate differences in the cloud turbidity factor. Functions of image diffusion were measured, and the spectra of spatial frequencies transmitted by the atmosphere in polarized light were found at two positions of the principal plane of the polaroid in the receiver. The resultant data confirm the possibility of improving image quality by polarization "cutoff" of multiply scattered light. Figures 3, references 7 Russian.
[105-6610]

BLOCK METHOD APPLIED TO CALCULATING OPTICAL BACKSCATTERING INDICES AND
SPECTRAL CURVES FOR NONABSORBING CUMULATIVE FRACTION OF ATMOSPHERIC
AEROSOL

RADYUK, I. M. and PRISHIVALKO, A. P.

[Abstract] Determination of radiation scattering characteristics in
atmospheric optics is complicated by polydispersity of scattering media.
A given characteristic is calculated by integrating the characteristics
for individual particles:

$$f_i = \int_{r_0}^{r_1} F_i(r, n, \lambda)\phi(r)dr, \qquad (1)$$

where n is the index of refraction of the material of scattering particles,
r is particle size, λ is the wavelength of the incident radiation, $\phi(r)$ is
the size distribution function of the particles, r_0 and r_1 are the limits of
integration. Considerable errors arise in numerical calculations if the
integration step is at all large. Determination of light scattering by an
elementary volume with consideration of contributions from particles measuring
up to $r_1 = 3$ μm at $\lambda = 0.6$ μm requires computation of more than 300 mono-
disperse characteristics. This situation can be resolved by condensing the
information required for finding the unknown polydisperse characteristics,
i.e. converting from the monodisperse characteristics to a data set with
smaller volume suitable for approximate calculation of the problem. The
authors propose a method of consolidation that gives an algebraic representa-
tion of relation (1). To do this, the distribution function is approximated
by first-degree Lagrange polynomials. Tests for determining the error re-
sulting from the algebraic transformation are worked out. A table is given
with consolidated data blocks suitable for calculating backscattering of
light with wavelength of 0.5 μm in lidar probing of the atmosphere.
Figure 1, table 1, references 9 Russian.
[100-6610]

CONVERGENCE OF SPECTRAL METHOD FOR SOLVING NONLINEAR OPTICS PROBLEM

KARAMZIN, Yu. N. and TSVETKOVA, I. L., Moscow

[Abstract] Thermal self-stresses due to inhomogeneous heating of the laser
crystal by an intense light beam are important in cw lasing on the second
harmonic. It is difficult to account for these effects in nonlinear
Maxwell's equations since new nonlinear terms appear in the second members
of the equations that describe the process. The authors propose an effec-·
tive spectral method for solving the problem of continuous lasing on the
second harmonic with consideration of thermal self-stresses and absorption.
A theorem is proved on the rate of convergence of the proposed spectral
method. References 4 Russian.
[111-6610]

OPTOELECTRONICS

OPTOELECTRONIC PROPERTIES OF ASTIGMATIC LENS MADE OF FLAT ELECTRODES AND OF
SYSTEM OF TWO SUCH LENSES

PETROV, I. A.

[Abstract] An experimental study was made of an astigmatic lens consisting
of three flat brass electrodes with apertures, a circular aperture in each
outer electrode and a rectangular one in the inner electrode. The electrodes
were 70 mm in diameter, 1 mm thick and spaced 15 mm apart. The measurements
were made on an optoelectronic bench by the method of two grids, first-
order properties measured with the aid of a PTU-28 television set and third-
order properties, i.e., spherical aberration directly on the screen. The
rectangular apertures were made 60 mm long and either 15 or 30 mm wide, the
diameter of the circular aperture in each case equal to the width of the
two rectangular ones. The optoelectronic characteristics of this lens, namely
dependence of the image position and parameters on the ratio of electrode
potentials and occurrence of one negative aberration coefficient, were found
to be similar to those f a crossed lens. A five-electrode doublet of such
lenses was found to have less optical power but also smaller spherical
aberration than a five-electrode doublet of crossed lenses. An astigmatic
lens is, furthermore, easier to construct and adjust, only coaxiality of the
electrodes and orientation of only one rectangular aperture having to be
maintained. Figures 4, tables 2, references 8: 6 Russian, 2 Western.
[124-2415]

DEPENDENCE OF OPTOELECTRONIC PROPERTIES OF CROSSED LENSES ON SHAPE OF
ELECTRODES

BARANOVA, L. A., SADYKIN, A. D., MUKHIN, V. M. and YAVOR, S. Ya.,
Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences,
Leningrad

[Abstract] A study of crossed electron lenses was made, of particular
interest being first-order properties and third-order spherical aberration.
Both aberration coefficients C_x and C_{xy} were measured on a single lens with
two kinds of corrector electrodes, namely with cruciform or square apertures
respectively. It has been found that either of the two coefficients can be
made negative depending on the polarity of the potential across the inner
electrode relative to that on the two outer ones. Both coefficients depend
on the ratio of sides of the apertures in each outer electrode and, with
the potential across the inner electrode lower than that on the two outer
ones, the overall spherical aberration can be minimized by adjustment of
this ratio. Figures 5, references 9: 8 Russian, 1 Western.
[124-2415]

FOCUSING PROPERTIES OF ELECTRIC FIELD BETWEEN CHARGED CONIC SURFACES

NIKIFOROV, I. Ya., KOZAKOV, A. T. and RABINOVICH, M. N., Rostov-na-Donu
State University

[Abstract] For the purpose of analyzing the energy spectrum of electrons
in electron spectroscopy it is possible to employ analyzers based on the
focusing properties of the electric field between the plates of a flat,
spherical and tubular capacitor. A study is made here of the focusing
properties of the electric between charged conic surfaces and it is demon-
strated that an analyzer based on this principle can be used for studying
the distribution of electrons in terms of energy and angle of emission while
the analyzer remains stationary relative to the specimen for all angles to
be analyzed. An expression is derived for the strength of the electric
field in a capacitor formed by two concentric circular cones with parallel
generatrices. An equation of motion is derived for an electron between the
electrodes in the plane passing through the axis of the cone. An equation
is obtained for the electron path, the solving of which makes it possible

to arrive at the geometrical dimensions of the analyzer and its optical
spectrum characteristics, the initial parameters to be assigned being the
position of the inlet slit on the surface of the inside cone and the dis-
tance between the analyzer's electrodes. For experimental purposes initial
parameters of X_0 = 95.5 mm for the position of the inlet slit and d = 10 mm
for the distance between electrodes were selected. A numerical solution
was found to the electron path equation by the Runge-Kutta method. It is
demonstrated that under specific conditions focusing of the first order
takes place and that the focusing angle, γ_f, depends on the half-angle of
the cone, α, and becomes larger, the lower α is. Focusing is directional,
i.e., electrons are focused within a specific angle of approximately 5 to
6 degrees and lie in one of the planes passing through the axis of the cone.
The lines of force of the electrostatic field lie in axial planes and are
directed normal to the surface of the cones; this prevents scrambling of
the field of electrons moving in various axial planes, making it possible
to analyze electrons in terms of angle without changing the position of the
analyzer relative to the specimen. Two experimental models differing from
one another in the dimensions of the inlet and outlet slits were tested
and the results showed good agreement with the theoretical conclusions.
Figures 4, references 17: 8 Russian, 9 Western.
[76-8831]

NOISE SUPPRESSION PROBLEM FOR IMAGES OF SPECIAL TYPE

YERMOLAYEV, A. G. and PYT'YEV, Yu. P., Department of Mathematics, Moscow
State University

[Abstract] An image is considered that is assigned by a square N x N
matrix of the form $A(\sigma) = A + \sigma B$, where A is the matrix of the ideal image,
B is the image of the noise, and σ is a small parameter. The number N is
also taken as a parameter of the problem, assumed to be "sufficiently
large." An examination is made of the problem of reconstructing the matrix
A from observed $A(\sigma)$ with large N and small σ. A matrix $A_k(\sigma)$ is constructed
such that $\|A_k(\sigma) - A\|/\|\sigma B\| \to 0$ $(N \to \infty)$. It is assumed that the norms of
matrices A and B have order $O(N)$, and that the minimum distance between
eigenvalues of matrix A^+A has order $O(N^2)$ as $N \to \infty$. Conditions are defined
for which the signal-to-noise ratio can be increased arbitrarily as N
approaches infinity. Figures 2, references 2 Russian.
[102-6610]

PLASMA PHYSICS

UDC 537.222.6

DYNAMICS OF EVOLUTION OF THERMAL INSTABILITY IN ANODE DURING PREBREAKDOWN
STAGE IN VACUUM

NEVROVSKIY, V. A., All-Union Scientific Research Institute of Metrological
Services, Moscow

[Abstract] Transient heating of an anode prior to breakdown in vacuum is
analyzed theoretically, heating as a result of thermal instability under
bombardment by electrons emitted by the cathode. The basic concept of an
earlier developed steady-state model is applied, namely that thermal in-
stability occurs when the thermal flux brought by field-emission electrons
exceeds a certain threshold level. The temperature rise at the center of a
circular anode surface segment is calculated as a definite time integral,
over the heating period, of an exponential function with time delay, taking
into account heat dissipation by conduction into the anode bulk but disre-
garding other modes of cooling by evaporation or radiation prior to avalanche
breakdown. Calculations have been made for a copper anode with either an
atomically pure surface or with a CuO coating film, also with prebreakdown
fluctuations of or step changes in the incident thermal flux. The time
delay of thermal instability at the anode is compared with that of thermal
instability at cathodic microasperities and with that of hydrodynamic in-
stability in the locally molten anode segment. Although the time delays of
both these instabilities are approximately equal, hydrodynamic instability
is not the mechanism likely to trigger breakdown in vacuum. Figures 5,
references 16: 12 Russian, 4 Western.
[124-2415]

MATHEMATICS

SYNTHESIS OF AUTOMATIC ADAPTIVE CONTROL SYSTEMS WITH REFERENCE MODEL FOR
NONSTATIONARY OBJECTS WITH TIME DELAY BY DIRECT LYAPUNOV METHOD

DZHAFAROV, E. M., Scientific Research and Planning Institute for Complex
Automation of Petroleum and Chemical Industries, Sumgait

[Abstract] Automatic control of objects whose parameters and gain vary in
time is considered, an adaptive regulator being added and a dynamic element
being selected as the reference model. The algorithm of regulator adapta-
tion is constructed with the aid of the Lyapunov-Krasovskiy functional, on
the basis of the quasi-stationarity hypothesis, for such an object with
time delay. The gain in the object is assumed to vary slowly during a
transient process and the equation of coordinate mismatch between object
and model is solved accordingly. The algorithm ensures stability of the
system with the model. For illustration, the method is applied to synthe-
sis of an automatic regulator for a first-order object with a negative-
definite first derivative of the Lyapunov function. Figure 1, references
6 Russian.
[126-2415]

SUFFICIENT CONDITIONS FOR PURSUIT IN THEORY OF DIFFERENTIAL GAMES

ARUTYUNOV, A. V.

[Abstract] The first of nine conditions imposed on a differential game by
L. S. Pontryagin ("Theory of Differential Games", USPEKHI MATEMATICHESKIKH
NAUK Vol 21, No 4, 1966 pp 219-275), the one most difficult to verify, is

interpreted here with the aid of a few additional assumptions. Three lemmas
are proved that lead to two theorems as to what is necessary and suffi-
cient for this condition to be satisfied. The author thanks
N. T. Tynyanskiy for continued interest in this study. References 3 Russian.
[122-2415]

PROBLEM OF PURSUIT BY SEVERAL OBJECTS

GRIGORENKO, N. L.

[Abstract] The quasi-linear differential game of m pursuers and one evader
is considered in a situation where each pursuer alone cannot catch the
evader but all pursuers acting in coordination can reach their aim within
a finite time. The problem is formulated as one of determining the suffi-
cient conditions for the game parameters under which, for a given initial
state, at least one of the m vectors will be the solution to the equation
describing the motion of all m vectors in an n-dimensional Euclidean space.
On the basis of certain assumptions, a theorem is proved with regard to
solvability of this pursuit problem. The method of solution is demonstrated
on two examples. In the first example of three pursuers one moves with
velocity control and two move with acceleration control, while the evader
moves with velocity control. In the second example of m pursuers all move
with velocity and acceleration control, while the evader moves with velocity
control. References 11 Russian.
[122-2415]

ADAPTIVE CONTROL OF SEMI-MARKOV OBJECT BASED ON INCOMPLETE DATA

ANDRIYANOV, V. A., KOGAN, I. A. and UMNOV, S. G., Saratov, Moscow

[Abstract] A semi-Markov object with a finite number of states is con-
sidered, each state corresponding to a closed bounded set of controls.
The problem is to determine the sequence of solutions to be taken at in-
stants of stepping from one state to another that will maximize the mean
payoff per unit time simultaneously for all initial states and any initial

distribution. This sequence of solutions or optimum strategy is sought
when the transient probabilities at the instants of stepping from one state
to another and the distribution of sojourn times in each state depend on
an unknown parameter. The semi-Markov object is assumed to be regular with
sojourn in any state with certainty not more than a finite number of times
within a finite period of time, and to consist of one ergodic class. First
control on the basis of complete data is considered, a lemma and four theorems
with four corollaries being proved regarding strategies and the central
limit. Next a model of adaptive control is constructed, with the support
of five additional theorems, where the unknown parameter will be estimated
by the method of minimum contrast. References 12: 4 Russian, 1 Hungarian,
7 Western.
[123-2415]

ASYMPTOTIC ENLARGEMENT OF QUASI-ERGODIC MARKOV PROCESSES

ANISIMOV, V. V., Kiev State University

[Abstract] Asymptotic enlargement of states of random processes involves
analysis of time-homogeneous Markov schemes. In a previous paper, the
author used an original formalism of switchable states to determine general
conditions of convergence of stepped sum processes to inhomgeneous Markov
processes that are homogeneous with respect to a second component
[DOKLADY AKADEMII NAUK UKRAINSKOY SSR: SERIYA A, No 12, 1981, pp 3-6].
This research is now extended to certain special classes of functions of
type $\{\hat{x}_n([nt]), S_n([nt])\}$, where $\hat{x}_n(m)$ is the enlargement of the process
with arbitrary state space, and $S_n(m)$ are sums of conditionally independent
variables. Figures 14 Russian.
[112-6610]

CLASS OF MANY-STEP CONFLICTS UNDER RISK CONDITIONS

KHALEZOV, A. D., Moscow

[Abstract] A theory of dynamic games has been developed within the
formalism of the theory of games with a fixed sequence of moves. However,
in contrast to static formulations, dynamic problems have been treated
only in deterministic control systems. In this paper, a class of hierarchi-
cal many-step two-person games is considered in which the players do not
have exact knowledge of the dynamics, but the second player learns the
exact value of the random parameter that determines the dynamics of the
system at the instant immediately preceding control selection. A
guaranteed strategy is constructed for the first player that is optimum
in a certain class. The problem is reduced to solution of a certain
antagonistic game (calculation of a penalty strategy) and a certain sto-
chastic optimum control problem. The optimum strategy is a certain set of
mutually advantageous trajectories corresponding to different realizations
of random parameters, and the penalty for deviation from them.
References 4 Russian.
[111-6610]

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